

REMARKS

The abstract and specification have been amended in order to correct grammatical and idiomatic errors contained therein. No new matter has been added.

In order to expedite the prosecution of the present application and more particularly point out and distinctly claim the subject matter which Applicants regard as the invention, Applicants have presented Claim 6 which contains the subject matter of originally presented Claims 1 and 4. Accordingly, Claims 1 and 4 have been canceled and the dependency of Claim 5 amended to depend on newly presented Claim 6. No new matter has been added.

The rejection to Claim 4 under 35 USC 112, second paragraph, has been overcome by newly presented Claim 6. Claim 1 has been rejected under 35 USC 103(a) as being unpatentable over Kondo et al in view of Uzoh et al and Maenosono. Claim 4 has been rejected under 35 USC 103(a) as being unpatentable over Kondo in view of Uzoh and Maenosono and further in view of WO '898. Claim 5 has been rejected under 35 USC 103(a) as being unpatentable over Kondo in view of Uzoh and Maenosono and further in view of Yoshida et al and Verbunt. Applicants respectfully traverse these grounds of rejection and urge reconsideration in light of the following comments.

The presently claimed invention is directed to an electroless copper plating method comprising the steps of preparing a pretreatment agent by reacting or mixing a noble metal compound and a silane coupling agent having a functional group with metal-capturing capability, pretreating a mirror surface having a surface roughness of less than 10 nm with a pretreatment agent prior to electroless copper plating, performing electroless copper plating on the pretreated mirror surface with an electroless copper plating solution comprising a first reducing agent, hypophosphorous acid or a hypophosphite as a second reducing agent and a stabilizer for

inhibiting copper deposition and forming a thin film having a thickness of no more than 500 nm on the pretreated mirror surface by the electroless copper plating.

As discussed in the present specification, the aim of the present invention is to provide an electroless copper plating solution which enables the uniform plating to be formed at lower temperatures on a mirror surface such as a semiconductor wafer. The present invention is based on the discovery that when a first reducing agent and a second reducing agent comprising hypophosphoric acid or a hypophosphite are used simultaneously in an electroless copper plating solution, the initial plating activity via a metal catalyst is higher and when a stabilizer to inhibit copper deposition is also used at the same time, excessive deposition reactions will be prevented and a uniform plating can be achieved at lower temperatures on a mirror surface having a surface roughness of less than 10 nm and it is particularly effective in producing a thin film having a thickness of no more than 500 nm. It is respectfully submitted that the references cited by the Examiner do not disclose the presently claimed invention.

The Kondo et al reference discloses an electroless copper plating solution and process for electrolessly plating copper utilizing a trialkanolmonoamine as a complexing agent or copper ion and as an accelerator and, optionally, additives such as potassium ferrocyanide, 2,2'-bipyridyl, polyethylene-glycol and an anionic surfactant.

In the outstanding Office Action, the Examiner states that the plating solution of Kondo et al can be formaldehyde in combination with sodium hypophosphite. However, Figures 9 and 10 of this reference suggest that the plating rate for formaldehyde and sodium hypophosphite is almost equal to that of formaldehyde alone. Sodium hypophosphite is added to formaldehyde in Kondo merely to reduce the content of formaldehyde, which is harmful to the human body and causes the plating bath to be unstable when used in large amounts (column 13, lines 30-45). As such, Kondo only discloses that

sodium hypophosphite can be used as a partial substitute for formaldehyde and that no unexpected results or effects occur when sodium hypophosphite is used in combination with formaldehyde.

Additionally, the Kondo reference has no disclosure with respect to the substrate being treated having a mirror surface with a very small surface roughness. In fact, this reference states that "generally, an article or substrate to be treated ... is pretreated (cleaned and mechanically roughened) ... ". This means that in the method disclosed in Kondo et al, the surface is not a mirror surface so there would not be any expectation that the method disclosed there would work for a mirror surface and it would be expected that the method disclosed there would only apply to substrates having a non-mirror surface.

In the Comparative Examples contained in the present application, use of formalin or glyoxylic acid alone without hypophosphorous acid or sodium hypophosphite produced inferior results. However, Kondo et al's plating solution provided for the composition of formaldehyde without sodium hypophosphite while the present invention requires the presence of both a first reducing agent and hypophosphorous acid or sodium hypophosphite as a second reducing agent. Therefore, the plating method disclosed in Kondo et al and that of the present invention are completely different in terms of effect and production steps.

The Uzoh et al reference discloses a method of forming conductor structures on a semiconductor wafer. The method comprises the steps of depositing a seed layer having a substantially consistent thickness over a barrier layer that covers the features in the filled regions, electrodepositing a planar copper layer on the seed layer and subsequently electro-etching it until a thinned seed layer remains over the filled regions. When another layer of planar copper is deposited on the remaining copper and the features and on the thinned seed layer on the filled regions, the structure

minimizes stress-related defects in the features which occur during a following annealing process.

The Uzoh et al reference has been cited by the Examiner as teaching that it is well known when providing copper electroless plating that it is desirable to overplate substrates formed from silicon wafers and that the desirable copper plating can be from 2-250 nm for a seed layer and 200 nm on a seed layer from a plating bath. However, the Kondo et al reference is concerned with articles or substrates having a chemically roughened surface. Therefore, the teachings contained in Uzoh et al would not be extended to Kondo et al by one of ordinary skill in the art.

The Maenosono reference discloses a support for a flexible magnetic recording medium made of a polyimide film obtained by coating a solution of a solvent-soluble polyimide resin on a solid substrate having a smooth surface, removing the solvent and then peeling apart a coated film from the substrate. In the process disclosed in Maenosono, a polyimide solution is applied to a polished inorganic substrate having a center line roughness of no greater than 10 nm, the solvent evaporated to form the polyimide film and then the film peeled off. The plating method disclosed in this reference is electrochemical deposition and not electroless plating as required in the present invention. Additionally, this reference states in paragraph [0030] "Such a thin film is preferably made of a material that the resistance (adhesion) during peeling apart the polyimide film after forming the polyimide film is low." This suggests that the deposited thin layer of Maenosono is not provided to adhere to the substrate, which is opposite to that of the present invention where the plated thin layer is to stably bond to the surface of the substrate. The mere fact that Maenosono discloses a thin film of another material may be formed on a substrate having a high flatness and centerline surface roughness of no more than 10 nm by electrochemical deposition would not suggest to one of ordinary skill in the art to combine Maenosono and Kondo et al

since there would be no expectation that Kondo et al's solution, which is designed to be used with a conventionally roughened substrate surface, would also be suitable for use with substrates having mirror surfaces as required by Maenosono. Moreover, as pointed out above, Maenosono is directed to electrochemical deposition and not electroless plating for forming the thin film on the surface of the substrate and then the subsequent removal of the deposited thin layer. Therefore, the combination of Maenosono et al with Kondo and Uzoh et al would not even present a showing of prima facie obviousness under 35 USC 103(a) with respect to the presently claimed invention.

WO '898 discloses a method for metal plating which comprises admixing or reacting a noble metal compound as a catalyst with a silane coupling agent containing a functional group having the capability of capturing a metal to prepare a pre-treating agent, subjecting an article to be treated to the surface treatment with the pre-treating agent and then subjecting the pre-treated article to electroless plating. This reference further discloses that the method can be applied to an article having a mirror surface, such as a semiconductor wafer.

WO '898 was cited by the Examiner as disclosing a desirable pretreatment agent to provide palladium on a surface with a mirror finish such as a semiconductor wafer by using a pretreatment agent containing a noble metal compound reacted or mixed in advance with a silane coupling agent having a functional group with metal-capturing capability. However, as pointed out above, since the Kondo et al reference is concerned with the plating of an article having a roughened surface, WO '898 does not cure the deficiencies with respect to combining Kondo et al, Uzoh et al and Maenosono as discussed above. Therefore, this combination of references does not even present a showing of prima facie obviousness under 35 USC 103(a).

The Yoshida et al reference discloses an electroless copper plating bath containing a cupric compound, a cupric ion complexing agent, a reducing agent, and a pH adjusting agent. A carboxylic acid is present as a reaction accelerator to accelerate the oxidation reaction of the reducing agent. Formaldehyde is not necessary as a reducing agent and yet the electroless copper plating bath disclosed there is said to have a plating reaction velocity equivalent to that of a bath containing formaldehyde as a reducing agent.

Yoshida et al was cited by the Examiner as teaching that it is known to exchange formalin for glyoxylic acid as a reducing agent in a copper electroless plating solution in order to provide a less problematic material and that glyoxylic acid has a structure similar to formalin and is believed to have an oxidation reaction mechanism similar to formalin although the plating reaction proceeds more slowly than with formalin.

The Verbunt reference discloses a copper bath composition for the electroless and/or electrolytic plating of copper which comprises water, copper ions, hydroxide ions, a complexing agent to inhibit the formation of copper oxides, copper hydroxides and copper salts, a stabilizer to control the rate of electroless copper plating, a reducing agent to promote the electroless reduction of the copper ions to copper metal and a catalyst to promote the electrolytic reduction of copper ions to copper metal. This reference has been cited by the Examiner as teaching that when providing copper electroless plating solutions, it is well known to provide hypophosphite in the form of sodium hypophosphite or to provide the hypophosphite from hypophosphorous acid.

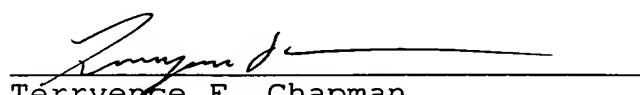
However, Verbunt and Yoshida et al do not cure the deficiencies contained in Kondo et al, Uzoh et al and Maenosono as discussed above and therefore these references in combination do not present a showing of prima facie obviousness under 35 USC 103(a).

Although the references cited by the Examiner do not present a showing of *prima facie* obviousness under 35 USC 103(a) with respect to the currently claimed invention, objective evidence is of record in the present application which is more than sufficient to rebut any showing of *prima facie* obviousness under 35 USC 103(a) made by the Examiner.

On pages 10-14 of the present application, seven Examples according to the present invention and three Comparative Examples are presented. The Comparative Examples all fall within the scope of the prior art cited by the Examiner. As discussed in paragraph [0043] of the present application, when hypophosphorous acid or a hypophosphite is used as a second reducing agent along with a first reducing agent simultaneously in an electroless copper plating solution, the initial plating activity via a metal catalyst is higher than when the first reducing agent is used alone, and when a stabilizer or inhibiting copper deposition is further used, excessive deposition reactions are prevented, to result in uniform plating at lower temperatures. This is clearly unexpected in light of the prior art cited by the Examiner and establishes the patentability of the presently claimed invention thereover.

The Examiner is respectfully requested to reconsider the present application and to pass it to issue.

Respectfully submitted,



Terryence F. Chapman

TFC/smd